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Observations on Drum Drying Mashed Potatoes

Fred H. Drazga and Roderick K. Eskew

Eastern Regional Research Laboratory, Eastern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture, Philadelphia 18, Pennsylvania

SUMMARY

Potato flakes (drum-dried mashed potatoes) are normally dried at drum speeds of about 2 to 3 rpm, to obtain a dense sheet. When mash is being dried to form a sheet for conversion to flakelets (a product of high bulk density), *sheet* density is relatively unimportant. The work shows that drum speeds up to 3 times those frequently used in producing flakes can be used in the flakelet process, with marked increase in dryer output and without impairing product quality. The interrelationships among drum speed, steam pressure, mash solids, dryer output, and sheet density are shown.

INTRODUCTION

Potato flakelets are a dense form of dehydrated mashed potato formed by laminating a fragmented sheet of drum-dried mash (Eskew and Drazga, 1962). Equipment requirements and costs involved in their commercial production have been described (Claffey *et al.,* 1961). This paper gives engineering data obtained in pilot-plant research on one of the most important steps in the process—drum drying of the mash. Fig. 1, a flow sheet of the entire flakelet process, shows drum drying in proper perspective.

Up to the point of cooking, the process is the now-familiar one of making potato flakes. After being washed and peeled with either lye or steam, the potatoes are trimmed, sliced, precooked, cooled, and then cooked in atmospheric steam until soft enough to rice. On emerging from the cooker the slabs are divided into two streams. One stream is riced, and the resulting mash is cooled. The remainder is also riced, and then drum-dried to a sheet containing about 10–15% moisture. After the sheet is broken to pass ¼-in.-diameter holes, it is thoroughly mixed with the previously cooled mash. This mixture, containing about 30% moisture, is compacted in the manipulator to form small laminates that, when dried, possess a bulk density of 40–50 lb per cu ft, depending on the moisture and the time employed in manipulation.

The proportions into which the stream of slabs must be split to obtain any desired moisture in the mixture to be manipulated will depend upon the moisture in the riced slabs and the moisture in the drum-"dried" sheet. If m represents the % moisture in the riced slabs, d the % moisture in the "dried" sheet, and p the % moisture desired in the mixture, the percent of slabs to be riced, cooled, and fed to the mixer will be:

$$\frac{100}{\dfrac{(100-d)(m-p)}{(100-m)(p-d)}+1}$$

The drum drying of mashed potatoes for making *flakes* has been studied by Cording *et al.* (1957). Their work, confined to drum speeds of 4 rpm and less, was directed toward obtaining the maximum product rate consistent with a dense sheet containing about 5% moisture. The desired sheet density (2.0–2.5 lb per 100 sq ft) could be had only at drum speeds of about 2–3 rpm. To obtain a product moisture of 5% at this drum speed it was necessary to use steam between 70 and 80 psi. Now that moistures of about 6–6.5% are typical for commercial flakes, it has become our pilot-plant practice to use steam pressures of 55–60 psi and a speed of 2 rpm to obtain comparable moistures when making flakes. This gives a dense sheet, but where high-solids potatoes are used and an emulsifier is added, the mash is "cottony." Therefore, to obtain good adhesion to the drum at the low surface temperatures corresponding to these pressures, the mash must be diluted to about 20% solids.

Commercially produced flakes are now made at 6–6½% moisture and drum speeds are generally between 2 and 3 rpm to obtain a dense sheet.

Although commercial flakes are a quite satisfactory starting material for flakelets, there are economies in preparing a sheet specifically for flakelets. In drum drying a sheet to convert to flakelets, the objectives are quite different from those that apply in flake production. The important factors are a continuous but not necessarily dense sheet, a moisture not exceeding about 15%, and high output. This paper indicates the optimum conditions for achieving these ends.

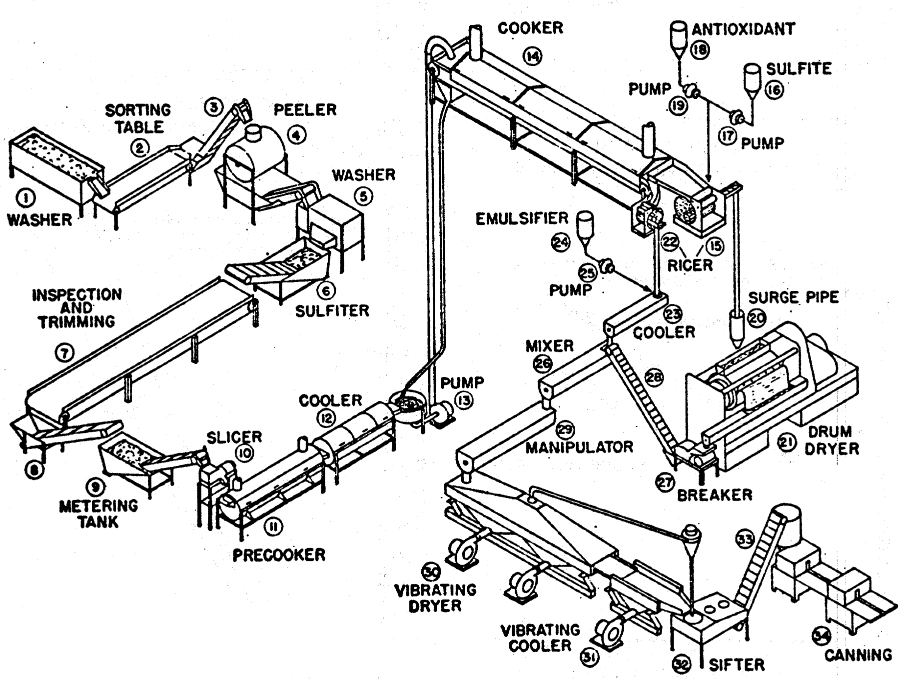

Fig. 1. Potato flakelet process.

EXPERIMENTAL

The dryer used had a drum 2 ft in diameter by 3 ft long with 4 applicator rolls, a prototype of those generally used commercially. Tests were designed to show interrelationships among drum speed, steam pressure, mash solids, dryer output, and sheet density.

The speed of the drum was set by adjusting a variable-speed-drive mechanism, and the temperature of the drum was brought to the test level by slowly increasing the steam pressure within the drum over a 15-min period. Test conditions having been established, mash was fed to the dryer until equilibrium was reached, then elapsed time was recorded for the feeding of 100-lb batches of mash. Flake production rates were taken for measured time intervals at equilibrium conditions. Solids content of the mash and of the flake was determined by analysis of composite samples taken over the period of test, using a Brabender moisture tester, Type FRA (no endorsement implied). Sheet density was calculated as follows:

(lb of moist sheet per hr $\times$ potato solids in sheet $\times$ 100) $\div$ (60 $\times$ rpm of drum $\times$ total drum surface excluding ends).

The bulk density of the product (flake lets) was determined by vibrating a no. 10 can while filling and then weighing the contents of the filled can.

RESULTS AND DISCUSSION

Fig. 2, from the work of Cording *et al.* (1957), shows how dryer output increases with drum speed in the range of 2–4 rpm. Fig. 3, from the same source, illustrates the sharp reduction in sheet density that occurs when drum speed is increased from 2 to 4 rpm. This accounts for the general use of 2–3 rpm in producing flakes, when sheet density is important. Since sheet density is not a primary factor in flakelet production, drum speeds up to 6 rpm were investigated. The marked effect of these higher speeds on drum output is apparent in Fig. 4.

Obviously, merely increasing drum speed can increase output only to a limited extent; steam pressure must also be increased, not only to provide the heat flux necessary to dry but also to maintain a drum surface temperature that is conducive to adhesion. Fig. 5 shows how increased drum surface temperature (actually expressed as steam pressure in the drum) increases drum output. This increase results whether the drum is operated at 2 rpm or at 6 rpm. It is apparent from Fig. 6 that, in the relatively narrow steam pressure range of 90–100 psig, drum output did not increase in direct proportion to increased drum speed. We attribute this deviation in part to the fact that at speeds above 2 rpm, available steam pressures were insufficient to provide the additional heat flux required by the increased amount of mash adhering to the drum. Moreover, the sheet moisture was in some cases so much higher than the desired maximum of 15%, that the increased output would be of no practical value. Although steam pressure above 100 psig would be conducive to lower moistures, a point would be reached at which the surface of the sheet next to the drum is so dry that the sheet becomes detached by its own weight before the desired average sheet moisture is attained. Thus, in the upper range of the drum speeds investigated, a drum output directly proportional to increase in drum speed is probably not attainable. The optimum conditions for obtaining maximum output of a sheet not exceeding 15% in moisture may involve mash dilution prior to drying. This is discussed later herein.

Effect of mash dilution on output. The addition of small amounts of an emulsifier to mashed potatoes before drying improves their texture on re-

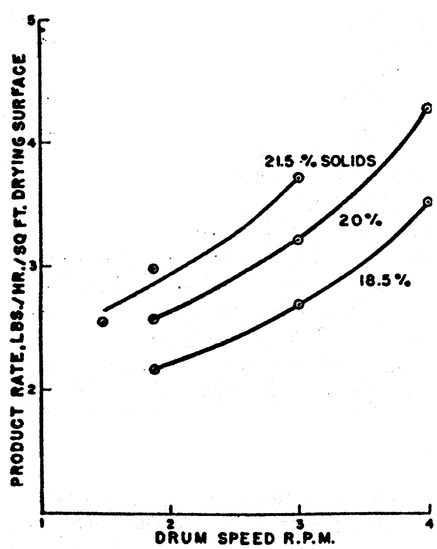

Fig. 2. Drum speed vs. dryer output.

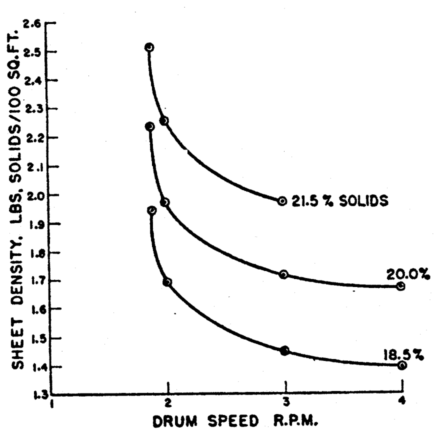

Fig. 3. Effect of drum speed on sheet density.

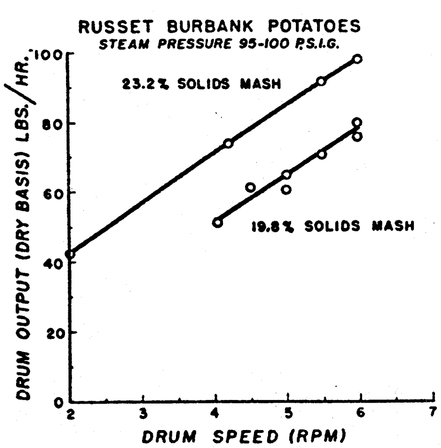

Fig. 4. Effect of drum speed on output rate.

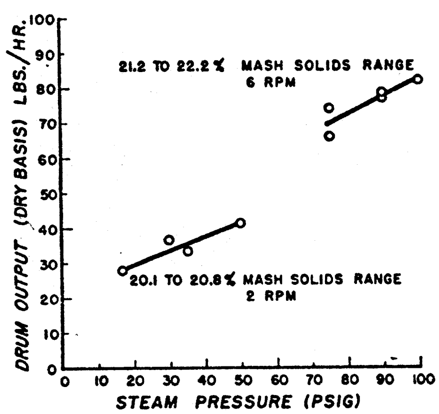

Fig. 5. Effect of drum temperature on dryer output.

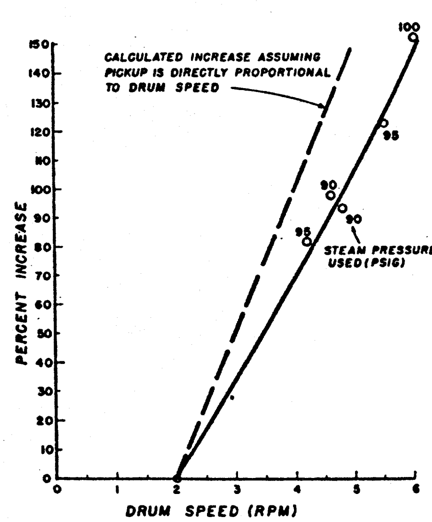

Fig. 6. Percent increase in drum output (dry basis) over output at 2 rpm.

hydration (Anonymous, 1959). But if high-solids potatoes are used, together with precooking and cooling, even as little as 0.25% emulsifier on a potato-solids basis may contribute a "cottony" character to the mash and hinder adhesion to the drum when flakes are produced conventionally. Mash dilution may even be necessary to maintain a good sheet. Since a sheet made expressly for flakelets may contain as much as 0.75% emulsifier, difficulties in adhesion might be anticipated, especially at high drum speeds. This, fortunately, is not the case. The data in Fig. 7 were obtained on un-

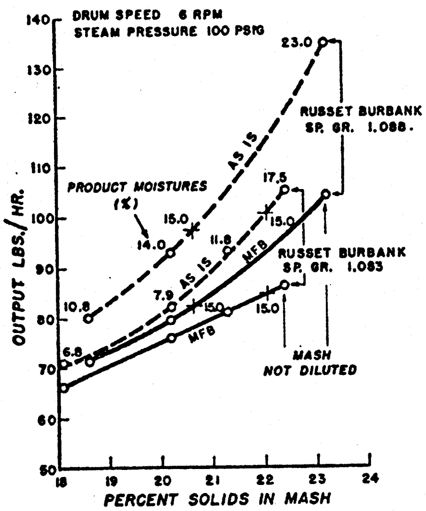

Fig. 7. Effect of dilution of feed mash on dryer output.

diluted mash and mash diluted to different degrees. In each case, 0.75% emulsifier was used. The potatoes were of two different specific gravities. It is apparent that the high drum surface temperatures corresponding to 100 psig steam, resulted in good adhesion to the drum even in the case of "cottony" undiluted high-solids mash containing 0.75% monoglycerides and at a high drum speed. Output was highest with undiluted mash. Dilution served to reduce product moisture. This is because, as mash solids are decreased, mash pick-up and net water pick-up are decreased. Thus, at a given steam pressure, product moisture will be lowest with the wettest mash.

As previously mentioned, the high output rate obtained at 6 rpm with high-solids mash was at the expense of dryness; moistures were at times well above the desired maximum of 15%. Unfortunately, it was not possible to determine whether higher steam pressure would have produced lower moistures or merely a larger output of insufficiently dried material.

The points corresponding to a sheet moisture of 15% are indicated in Fig. 7. These show that maximum dryer output when making a sheet for flakelets of Russet Burbank potatoes requires that the mash be diluted to about 21% solids, depending on the solids content of the potatoes. The drum should be operated at 6 rpm, using 100 psig steam. These are pilot-plant data and may not be directly translatable into use with large dryers. The principles, however, would still apply.

Sheet density. Numerous tests have shown that a sheet of approximately 1.2 lb per 100-sq-ft density (such as results when operating at 6 rpm) broken through 1/4-in. holes in a sharp-knife hammermill gives a bulk density of about 20 lb per cu ft. Using the same drum dryer and operating at 2 rpm and breaking in the same manner, gives a product having a bulk density of about 25 lb per cu ft. The corresponding weights that could be packed in a no. 10 can would be about 2.2 and 2.7 lb. In a plant producing about 800 lb/hr of flakes, this would represent an increase of about 1.2 cents per lb in packaging costs if the drum dryer were operated at 6 rpm

Table 1. Effect of sheet density on bulk density of flakelets.

Dry sheet density (lb/100 sq ft)	Manipulation[a] moisture (%)	Bulk density of product (flakelets) (lb/cu ft)
0.25	28.2	44.1
1.00	29.6	47.0
1.10	28.8	45.0
1.10	30.0	45.9
1.10	29.6	46.5
1.10	29.6	47.0
1.73	28.4	42.5
1.73	29.8	45.2

[a] A planetary mixer was used as a batch manipulator.

instead of 2 rpm. Thus it would appear that, unless (through the use of higher steam pressures) a flake manufacturer can obtain higher sheet densities than are reported here, he could not economically avail himself of the higher drum speeds recommended for use in making flakelets.

As shown in Table 1, the density of the drum-dried sheet has no significant effect on the bulk density of the resulting flakelets when manipulation is carried out within the typical range of 28–30% moisture. The textures of all the reconstituted products were good, regardless of the density of the drum-dried sheet from which they were made.

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